CIRCULAR LIII.

Pure Drinking Water---How to Secure It.

The importance of having a pure drinking water is such that every care should be taken to secure a good water supply, and then to keep it pure.

Impurities are either animal, vegetable, or mineral. Where the organic matters are animal, they tend to become putrescent, and when taken into the system may produce fever or other disorder. When the matter is introduced in smaller quantities, it undergoes decomposition more or less rapidly according to the condition of the air or temperature. In such cases no smell or taste may be perceptible. The constant use of such water sometimes causes disease, even where the quantity is small. Some persons seem more susceptible than others, and their own systems either cause or accelerate changes which had not been noticeable before. Vegetable impurities also tend to decomposition under favoring conditions. These disorder the system, or cause malaria or other special forms of disease. Mineral impurities are owing to the suspension or solution of mineral particles in the water. Some of these, as sulphur or iron, give taste to water, but do not injure it unless present in too large quantities. Others, as lead, may in small quantities seriously affect the human system. Others, as lime, are chiefly injurious by producing too great hardness of water. The taste of water fresh from the well is not by any means a perfect guide as to its purity. If it has much organic matter in it which is already undergoing decomposition, there may be taste and odor, or its organic impurities may have been so far destroyed as to yield no unpleasant taste or odor, and yet there may remain some dangerous contamination. Its being an agreeable drinking water to those accustomed to its use does not prove its purity.

Water as it comes from the clouds and is strained through the ground is so nearly pure that it is generally good, except where wells and springs are in some way fouled by nearness to houses or pits of decayable material. In cities, where the soil is likely

to become filled with decomposable matter to a degree that the ground, the air, the sunlight and vegetation cannot rapidly remove it, the water generally becomes impure.

The usual supply of drinking water naturally divides into public water supply, cisterns and wells or springs. Where there is public water supply, the only way is for companies to have from time to time proper examinations made, and, if the quality is not what it should be, to know the cause and to apply the remedies, so many of which are now available. The general water supply, which has been good, may come to be impure. It may have too much sewage put in the river, or the pipes may become fouled, or these or the reservoirs may have growth of minute forms of plant-life, or water long impounded and in great quantities may become deadened by want of oxygen or air in the water. Thus water, from a good source, may become fouled in its distribution. Proper reservoirs and filtering basins and the introduction of compressed air into the impounded water, will do much to correct any temporary deterioration.

Where cistern water is relied upon, the first care must be exercised to receive it from a clean roof, to see to it that the first water of a rain does not go into it, and that the main supply is derived from long and heavy rains, rather than from occasional showers. If a leader ends in a hogshead or tank proportioned in size to the water capacity of the roof or its single leaders, and is arranged with an overflow tube to the main cistern, or with an automatic float, it will, when nearly full, divert the purer water into the main cistern, and leave the former to be used for non-drinking purposes. Cistern water, unless collected and kept with care, may be charged with organic matter. The cistern should in size bear proportion to the needs of the family, so that it can be empty enough to be cleaned twice a year. If in the ground, it should be tightly cemented and kept so well covered that small animals and foul gases cannot enter it. The pump fitted in it should be of metal When it is claimed that air should be admitted to the cistern, it is best to have an upright shaft of a few feet, in the top of which there is a wire gauze to protect from leaves, etc.

Wells and springs must be most carefully protected from any possible defilement. To this end, it must be remembered that it is not safe to place any well within one hundred feet of any cess-

pool, privy, cow or pig-pen, or other deposit of foul matter. Sometimes, without knowledge of where these have been before, wells are dug in too close proximity. The well should be carefully stoned or bricked, and for at least four feet from the top the bricks should be laid in cement, and come up higher than the surrounding ground. The soil should not be rich just about the well. The cover of the well and its pump should be such as not to admit any foul matter. People are too often careless in rinsing vessels about a well. Even a cistern may be defiled by the soil or spillings about it, and wells often are. The cistern may have crevices, or may have something fall into it, or may have its water become dead by long standing. The well may have its surrounding soil so saturated with decaying material as finally to become unable to oxidize it. Some new crack or underground rill may let into it foul liquid from sources that have never reached it before, and which are especially liable to reach it in dry weather. The same may, more or less, happen to springs. Therefore, it is not enough to say that a water supply has been good, as it may have suddenly become bad from causes not visible. Where, because of sickness or for other reasons, there is suspicion as to the purity of the water, resort should be had to some simple tests, or at once to chemical or biological examination.

Here are a few tests which, without all the appliances of a chemist, may much aid in indicating whether further examination is necessary, or whether it is wise to cease using the water until fully examined:

Color.—Fill a clean, long bottle made of colorless glass with the water; look through the water at some black object; the water should appear perfectly colorless and free from suspended matter. A muddy or turbid appearance indicates the presence of soluble organic matter or of solid matter in suspension.

Odor.—Empty out some of the water, leaving the bottle half full; cork up the bottle, and place it for a few hours in a warm place; shake up the water, remove the cork, and critically smell the air contained in the bottle. If it has any smell, and especially if the odor is in the least repulsive, the water should be rejected for domestic use. By heating the water to boiling, an odor is evolved sometimes that otherwise does not appear.

Taste.—Water fresh from the well is usually tasteless, even

though it may contain some putrescible organic matter. Water for domestic use should be perfectly tasteless, and remain so even after it has been warmed, since warming often develops a taste in water which is tasteless when cold. If the water at any time has a repulsive, or even disagreeable taste, it should be rejected.

As some waters of dangerous quality fail to indicate their impurity either by smell or taste, what is known as the Heisch test is of value: Fill a clean pint bottle three-fourths full with the water to be tested; add to it a half-teaspoonful of clean granulated or crushed loaf sugar; stop the bottle with a glass stopper or a clean cork, and let the bottle stand in the light in a moderately warm room. If in twenty-four or forty-eight hours the water becomes cloudy or milky it is unfit for domestic use. While cloudiness in the water after standing certainly indicates unfitness for use, yet a negative result does not *prove* the water to be good; because the test often fails to indicate organic matter really present, if phosphates are absent.

CHLORINE IN WATER.—The following test for chlorine is also available in the hands of some physicians. It is distinctly understood that the results are approximate. A larger proportion than two grains to the gallon in well waters is a just cause for suspicion of the character of drinking water. Therefore, if you find more than that proportion, examine the well and its surroundings, and in case of sickness forbid use till examined more in detail by other tests. It may happen that less than one grain to the gallon is the normal quantity of chlorine in certain localities, so that it would be well for the examiner to acquaint himself with the normal proportion for the various districts under his care. Any chlorine in excess of the normal amount is suspicious.

CHEMICALS REQUIRED—Nitrate of silver, (pure crystalized; chromate of potash (not *bi* chromate; its color YELLOW, not *red*); distilled water, that from condensed steam of factories, or furnished by druggists, or, better, collected from the domestic tea-kettle by simple device into clean glass bottles.

NOTE.—Always test your distilled water by a drop of the nitrate silver solution. It should give no cloud.

APPARATUS.—A glass-stoppered colored bottle, or one covered closely with dark blue paper for your nitrate of silver solution, capacity, 1 pint; another ordinary 16-ounce glass-stoppered bottle for chromate potash solution; a white porcelain evaporating

dish of 8 ounce capacity, or smooth, white china bowl, or deep soup plate will do as well; a drachm measure divided into minims.

To prepare the solutions:

SILVER SOLUTION.

Nitrate of silver, (cryst.) grains, 50; distilled water, 13 ounces; in colored or covered glass-stoppered bottle, as above.

One drachm of this solution is equal to one-tenth (.1) grain of chlorine. *Weight and measure must be accurate.* Remember, in collecting and testing water, all containers must be clean and then rinsed in the water in question.

CHROMATE SOLUTION.

Chromate of potash, 4 drachms; distilled water, 16 ounces.

Label your solutions and provide 4 ounce glass-stoppered bottles, prepared as above, for use, refilling as required from the larger ones.

To apply the chlorine test: Pour in the clean dish or bowl, 8 ounces of the water. To that add a drachm of the chromate solution and mix, with a clean broken thermometer tube or other clean glass rod. The water will have the bright yellow color of the chromate. Into the clean drachm measure put exactly 1 drachm of nitrate of silver solution. Pour it, drop by drop, into the colored water, stirring well after each drop. So long as the red color produced by the silver disappears entirely on stirring, continue dropping, but the moment it gives a permanent reddish tinge, however faint it may be, to the water, your test is made. Read the number of minims you have used. The drachm represents the tenth of a grain in 8 ounces, or 1.6 grains per American gallon. Therefore, 30 minims = .8 grains per American gallon; 15 minims = .4 grains per American gallon, and so on. A water which takes more than 1 drachm of the silver solution contains more than 1.6 grains per gallon. You can tell how much more, by taking another drachm of the silver solution and proceeding as before, on the same sample, till the red color is permanent. Suppose it takes 30 minims more, you would then have used 1.5 drachms = .15 grains chlorine in 8 ounces of the water, or 2.4 grains per American gallon. Figure the same way for any other proportion.

FORMULA—Multiply .1 by the amount of silver solution in drachms and fractions of a drachm which are required for the

test; this gives the number of grains of chlorine in 8 ounces of the water. That, multiplied by 16, expresses the chlorine in grains per American gallon.

NOTE.—Grains of *chlorine* per American gallon can be reduced to grains of *salt* per American gallon by multiplying by 1.65.

Water thus found impure should not be used until further tested either by the usual chemical methods, or the additional gelatine method proposed by Koch. Even where water is suspected, it is much better not to use it for drinking purposes until it has been boiled and poured several times from one vessel to another to aerate it. Or if boiled and passed through a filter, similar aeration takes place. Alum has considerable power as a purifier of water, as it combines with albumen, etc., and removes or settles the organic matter. As, when taken in much quantity or continuously, it affects the health and causes disturbance of the digestion, its popular use has been generally discouraged. But good authorities claim that even if an amount of two grains to the gallon be well stirred through the water and it be allowed to stand a few minutes, it will do much not only to clear it but to dispose of the organic matter, and that this amount can have no ill effect.

Where it is found desirable to have further chemical testing of the water, two or three quarts of it should be put in a new bottle, which has been thoroughly rinsed several times with the same water that is being collected. The bottle should be plugged with an *absolutely new*, clean cork, previously well washed in the same water, and this bound over with a strong string, sealed with sealing-wax so that it may not be disturbed in transit. When the water is taken from a river or open spring, it should be dipped out below the surface; if taken from a pump or faucet, the water should first be allowed to run, so as to fully cleanse the pump or pipe. The sample should be sent to some chemist who has full laboratory facilities, and who has a reputation for correct analysis.

Hardness of water is so fully treated in the 8th report of this board (1884) that we shall not consider it here. It must be remembered, however, that this and other mineral conditions are injurious to some persons.

Refer to the index of each State Report of the Board of Health as to water.

FILTERS.

Water which is discolored or impure in some form which may not be injurious, often needs to be filtered. Also water which contains organic matter can be much improved by passing it through filters.

Cisterns are often well provided with filters of their own, by having a partition of brick, so that the water is passed into one side and drawn through the other. A solid brick wall laid carefully in cement mortar, makes a good filter. The bricks should be rather underburned, and extending through from one side of the wall to the other, and the faces of the wall not covered with mortar. Water will filter through such a wall fast enough for the supply of a family, and if the rain all enters the cistern upon one side of the wall and is drawn out upon the other side, the water is clean and sufficiently pure. Such cisterns should be occasionally cleaned out and the partition wall scrubbed. If, by an ordinary bellows, air is blown through the brick septum from the side opposite to that on which the roof water comes in, it helps to restore its straining power.

There are various forms of house filters, some of which are cheap and valuable. Flannel tied on the faucet of the water pipe will greatly improve the appearance of drinking water, and will strain out much organic matter. A tube or box with sponge in it will also be satisfactory in clarifying turbid water, and it is easily and quickly washed and replaced. A sheet of filtering paper as used by druggists and a glass or tin funnel furnishes a good means of filtering water on a small scale. A fresh sheet of filtering paper will be generally needed each day. Granulated animal charcoal, in boxes or vessels where the water can filter slowly through it, improves its appearance and quality. The chief idea of a filter is well illustrated thus:

Take any common vessel perforated below, such as a flower-pot, and put a small, clean piece of sponge over the hole. Fill the lower portion with gravel stones, over which place a layer of finer gravel and on these a layer of clean, coarse sand, the proportion of each being about the same.

On the top of this place a lid of unglazed clay, either very porous or perforated with small holes, and on this a stratum three or four inches thick of well-burnt, pounded animal charcoal. A

filter thus formed will last for a long time, is easily cleaned, and will be found to act both by mechanical and chemical purification.

The following are good directions from so good an authority as Dr. Parkes:

"The filtration of water is not difficult, even if you cannot afford to buy a regular filter. The compressed charcoal blocks are cheap and good; if they clog, rub them gently with a towel, or, if that does not clear them, with a hard brush; if they are still clogged, they must be gently scraped with a knife. But if the charcoal block is too expensive, a simple filter can be made as follows: Get a common earthenware garden flower-pot; cover the hole with a bit of zinc gauze or a bit of clean-washed flannel, which should be changed from time to time; then get some rather small gravel, wash it very well and put it into the pot to the height of three inches; then get some white sand and wash it very clean, and put that on the gravel to the height of three inches; then buy two pounds of animal charcoal, wash that also by putting it into an earthen vessel and pouring boiling water on it, then, when the charcoal has subsided, pour off the water, and put some more on for three or four times. When the charcoal has been well washed, put it on the sand and press it well down. Have four inches of charcoal if possible. The filter is now ready, pour water into the pot, and let it run through the hole into a large glass bottle.

"After a time the charcoal will get clogged; take off a little from the top and boil it two or three times, and then spread it out and let it dry before the fire. It will then be as good as ever. From time to time all the charcoal and the sand also may want washing. The sand may be put over the charcoal, and not between it and the gravel; but this plan sometimes leads to the charcoal being carried with the water through the gravel and out of the hole. The sand stops it.

"By filtering in this way, and by boiling the water, many dangers are done away with.'

Another similar suggestion is as follows: It is that of a simple glazed earthenware jar, holding five gallons, or even less, having a double bottom. The upper bottom has a small hole closed by a bit of sponge; the space of four inches or so between the two bottoms is packed with clean gravel, above which is fine

clean sand; the lower bottom is perforated with very fine holes through which the water slowly passes to an earthenware vessel below, into the top of which the filtering vessel tightly fits. The water is drawn off from the lower vessel by a faucet. If this lower vessel is unglazed it will serve at once as a cooler and reservoir. Such filters and reservoirs are now largely made, except that the reservoir is also glazed, necessitating in summer the use of ice, for such filtered water is very flat at first.

Another form of filter, as suggested in the last report of the State Geologist, is as follows:

"The most practical form of filter for household use, and one that will easily filter a pitcher full of water in a short space of time, can be made out of a bottle. The best form is the long kind in which sweet oil is sold, although almost any kind of glass or earthenware bottle will answer. The bottom of the bottle is cracked off, and the sharp edge removed by rasping with a file. The cracking can be done by tying a thin, soft string, soaked in turpentine, around the place where it is intended to crack, leaving as small a knot as possible, then setting fire to the turpentine, holding the bottle bottom up. After allowing the oil to burn for an instant, the end of the bottle is placed quickly in cold water, when, if the operation has been rightly conducted, an even crack will be produced, and the bottom of the bottle will come off easily.

"A layer of cotton is now placed in the bottle. The cotton must be worked in water, preferably warm water, in order to remove the adhering air, and to wet it well. A wad of the wet cotton is dropped into the bottle and covers the mouth of the neck. Other pieces are dropped in, care being taken to build the layer up evenly, and to add the cotton in rather small pieces. After dropping them in, they should be pressed down and arranged by means of a rod. In this way a layer is made which should be from two to three inches thick. It should not be pressed down too tightly, else it may filter too slowly; neither should it be too light, or water may form channels through it. After a little use the plug generally adapts itself. Particular care should be taken to be sure that the cotton is snug against both sides, since the water is liable to escape there. The plugs, however, are easy to make, and a few attempts will soon teach one all the necessary manipulations.

"This bottle filter can be suspended or supported in any convenient way. Perhaps the simplest support is a block of wood having an auger hole bored through the centre, and the edges of the hole reamed out. In this hole the bottle sits securely, and the bevel of the hole catches the shoulder of the bottle, thus holding it upright."

It is advised that the water to be filtered should be well stirred with alum added in the small amount heretofore named (two grains to a gallon, or one-quarter of an ounce to fifty gallons), and this poured through this filter pipe. It will run through in a considerable stream from the bottom, and can be caught in any convenient vessel, or a water holder both above and below can be combined with a filter thus made so as to be movable. The cotton used is simply the usual cheap white cotton batting. It makes a coherent filtering layer, and when clogged by use can be cleansed by boiling up in water and rinsing, or, as it is so cheap, can perhaps as well be thrown away and replaced by new.

Such precautions, and even boiling of water before such filtering, are worthy of thought, not only when any wide-spread epidemic prevails, but also when there is any good reason to suspect impurity of water supply. It is to be remembered that wells once found good generally remain good, unless they receive foreign matter from errors on the part of their owners, which is too often the case.

Where there is the least suspicion of the well water, it is best first to consult the family physician, who may aid in the more simple tests; but if there is good reason for suspicion he will advise you not wholly to rely upon these approximate results, but direct you to those who have more experience in the work, and the advantages of laboratories with all appliances needed.

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Copies of this and other Circulars can be had for distribution by addressing postal to E. M. Hunt, Secretary, Trenton, N. J.